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ABSTRACT

This paper focuses on the evidence of learning in children engaged in small-group discussion with a teacher. The children are considered to have learned if they show progress in the explanations they make, the language they use in the dialogue, or the understanding they show of the dialogue. Motives of the participants in this dialogue are analyzed and the teaching-learning process is considered to be the resolution of productive misunderstandings between everyday notions and scientific notions. The concluding discussion draws implications and raises questions about the role of the teacher in scientific dialogue. It is proposed that teachers might understand their role partly as a learner investigating the children's understandings, and partly as a guide who validates productive ideas and introduces scientific language to help the dialogue advance. Strengths of activity theory as an analytical tool for the classroom discussed include action-on-dialogue as a unit of analysis and activity system for the analysis of a community in dialogue. Contains 26 references. (Author/PVD)

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Scientific dialogue as evidence of learning

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Scientific dialogue

as evidence of learning

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This paper looks at the evidence of learning of children engaged in a small group discussion with a 'teacher' (the author). For the purposes of this analysis, I assume the children have 'learned' if they show 'progress' in the explanations they make, the language they use in the dialogue or the understanding they show of the dialogue. Consensual statements may be thought of as reflecting some learning by each individual in the agreement, though this evidence is weaker.

The analyses of the same event by Groves (1997) and Doig (1997) implicitly assumed this was a classroom situation in which a teacher is engaged in teaching science. In this paper I expand the context, use my privileged position as a participant to set the behaviours in the context as I saw it, and find new meanings for what we have seen.

Y. Engestrom (1994) develops a critical theory of mathematics education, which calls for classroom practices and analyses which he calls 'expansive'. Adopting his notion of an activity system, especially as developed by R. Engestrom (1995) and Wells (1996) for discourse analysis, I look at the motives of the participants in this dialogue, and consider the teaching-learning process as the resolution of productive misunderstandings between everyday notions and scientific notions, in Vygotsky's sense.

The concluding discussion will draw implications and raise questions about the role of the teacher in scientific dialogue. It is proposed that the teacher might understand their role partly as a learner investigating the children's understandings, and partly as a guide who focuses on or validates productive ideas and introduces scientific language to help the dialogue advance. Finally I discuss two strengths of activity theory as an analytical tool for the classroom: the notion of action-on-dialogue as a unit of analysis, and the notion of activity system for the analysis of a community in dialogue.

Introduction

This paper, with Groves (1997) and Doig (1997), form part of a study which sought to tackle the thorny problem of the role of a teacher in discussion in primary school mathematics and science classrooms. All three studies relate to the same example of a dialogue, but analyze it from different perspectives. Here I will look at the scientific dialogue for evidence of children's learning. The motivation is obvious. If one is to say anything to teachers about their role, one had better relate it to the childrens' learning!

I will look at the evidence of children learning through dialogue, and reflect on the role of the dialogue and the teacher's intentions and impact on it. Then I will discuss the teacher's role and consider how the teacher's notion of teaching might be constructed to provide an understanding of how to be effective in dialogue.

Finally I will reflect on the theoretical debate between socioconstructivism and activity theory in the light of the analysis. Two practical gains from activity theory for the analysis of within-classroom interaction will be explained.

The Context

This paper refers to an episode in one of a number of sessions in which I worked with such groups, and with the class as a whole. My purpose was to trial activities, to listen to the range of responses of the children, and hence gain insight into the 'children's science' and how it might be developed. Where it seemed appropriate I would attempt to 'teach', and on the basis of evaluation of these experiences I would develop the activities. My view of teaching here is that it should be an attempt to lead the children's conversation, building on the most productive ideas in the group, to a more sophisticated understanding of science and modes of scientific explanation of force and motion.

This research process has some things in common with the 'constructivist teaching experiment' (Cobb & Steffe, 1983; Steffe & D'Ambrosio,1996). The obvious difference is that I deal with a group of children and am at least as interested in their interaction with each other as in their interactions in a teaching episode. Another difference is that I am engaged with them over a more limited time. There is therefore considerably more uncertainty and more degrees of freedom in my 'experiment'.

The advantage is that it may have more validity as preparation for classroom teaching, since it includes within it the dynamic of peer interaction and teacher-children interaction. The disadvantage is that, as in real classrooms, we can be less sure of the individual's development. This is relevant for the following analysis because I ask the question here "what can be said about the learning of the individual?".

The process has some of the characteristics of 'dynamic assessment' in the sense of Feuerstein (for example Blagg, 1991; Feuerstein, 1979). My judgement of the scientific thinking of the individuals here is through an attempt to teach, and

hence is more a measure of what they can learn than what they know. This kind of assessment originates with Vygotsky's notion of zone of proximal development: according to Vygotsky, "research indicates that the zone of proximal development has more significance for the dynamics of intellectual development and for the success of instruction than does the actual level of development" (Vygotsky, 1987; p. 209). It also connects with metacognitive pedagogies based on cooperative group learning (for example Adey & Shayer, 1994).

Clearly, it is a methodology more consistent with research questions concerned with pedagogy rather than with individual development; one is interested in individuals as social beings, in fact as learners in classrooms. This Vygotskian perspective emphasizes that the intermental structure is primary in time and in fact, and the intramental development is an internalization of the intermental. Thus conflicts and formulations arise in the dialogue before they can be internalized by the individual engaged in it. And the teacher's key role in such dialogue is to ensure that scientific concepts are made concrete for the children through their attachment to the children's everyday conceptions; in this sense the development of scientific and spontaneous concepts take opposite paths (Vygotsky, 1987).

Some have argued that the logical development of this approach (for example by Davydov) leads to a de-emphasis on the personal construction of meaning by the individual. For instance, Cobb, Perlwitz and Underwood (1996) argue it may be inadequate if "it starts out at too high a level" (p. 38). But both Cobb, Perlwitz and Underwood (1996) and Steffe (1996) argue that constructivism can be reconciled with this apparently conflicting perspective by 'including Piaget's genetic epistemology in sociocultural theory' (Steffe, 1996, p. 79) or by developing a reflexive analysis of the classroom level (essentially constructivist) theories with the macro-social and cultural (essentially activity systems) theories (Cobb, Perlwitz & Underwood, 1996, p. 55). Without disputing Steffe's point, the latter seems controversial, as in sociological analyses the micro and macro can be seen as artificial and unhelpful distinctions in methodology. Conversational analysis and ethnomethodology explicitly link the two (see Boden & Zimmerman, 1991).

Although the Vygotskian social perspective is emphasised here because we need a theory of teaching and pedagogy, it should be held accountable in terms of learning, which is understood to be the active construction of the individual. And indeed it will become evident that the role of the teacher is that of a constructor of meaning too.

In particular in this research I am interested in groups of learners responding to certain activities, in the features of activities to which they attend, in the role of their mathematization, and the explanations which they can construct together or with some help from an 'expert' (see Doig, Groves & Williams, 1996). It is only because I accept this role as a teacher that the discussion has any validity as analysis of scientific dialogue with a teacher.

For example, in the episode discussed here a group of four children were involved in a task involving dropping a timer-ball. They discovered that the ball

would fall 90 centimetres in 0.43 seconds, and that this was consistent. (The ball had a stop watch in it and the degree of accuracy and consistency was clear.) Having guessed that it would take double the time from double the height, they in fact found that it only took 0.63 seconds from 180 cm. This conflict provided the problematic for the ensuing discussion.

In this discussion I place the student's elicited explanations in the most prominent place in the dialogue, and thereby hope to avoid the criticism of a top-down approach (Gravemeijer, 1991, cited in Cobb, Perlwitz & Underwood, 1996).

I am especially interested in the way in which the group may construct solutions together which might advance individual learning. Cobb, Yackel and Wood (1992) refer to the learning of individuals through small group interaction as follows: "the children learned in classroom situations as they participated in the interactive constitution of the situations in which they learned" (p. 119). This circularity reflects the nature of dialogue as both the object on which the participants act when they make an utterance, and the object on which they reflect when they try to make sense.

Indeed R. Engestrom (1995) views individuals in communities in dialogue as an activity system (in the sense of Y. Engestrom, 1994; 1996), in which the utterance is an action on the dialogue (which is constituted by the collection of utterances which went before). The 'action', in activity theory sense, is mediated by the social language of the community, it's rules and genres of speech (Leont'ev, 1981). In sociocultural theory these mediational means and systems provide for acculturation (Wertsch, 1994), and this in turn allows us to speak of learning, or progress, as opposed to simply 'change'. The teacher, usually the most educated participant in the classroom dialogue, has an important role in this acculturation, and may be thought of at one level as a mediator of culture. Also, at another level, the teacher is a subject in action in the dialogue. Finally, at the intramental level the teacher is a constructor of meaning, if one grafts a Piagetian perspective into the activity theory as Steffe (1996) suggests.

But one significant aspect of the utterance as the unit of analysis lies in personal motivation. There can be no action in activity theory without a motive to achieve an outcome (Leont'ev, 1981). The meaning of the dialogue thus only emerges when we understand the broader context of the dialogue, its participants and their motivations.

In the following I therefore look at each participant individually to try to assess their learning. In so doing, I make liberal use of my wider knowledge of the children, the school and the event in which this took place. Although this is unverifiable, I offer it as interpretation which you will believe if and only if it helps to makes sense of the data. For instance, you cannot understand the dialogue fully unless you know that Daniel has small hands.

Analysis 1: Daniel struggles with the data

Daniel has small hands. His teacher tells him "great presents come in small parcels". But Daniel is not so sure. The problem is that he finds it difficult to hold

the timer-ball used in the practical activity which preceded the discussion. Consequently Daniel had a lot of difficulty in getting sensible data. The conflict motivating the discussion doesn't arise unless you believe your data. This explains why all Daniel's bids to shift the centre of the dialogue are towards doubts about the data. In the context of progress of the discussion, this moves it backwards!

In his first explanation he offers two reasons for doubting the data in one sentence:

Daniel I think it's quite good because we was planning to get 60, um 86, so that's 20, 23 away which means that we should have gone a bit higher but we measured, we doubled it, but from here it doesn't look the same length from the 43 downwards.

This interjection involves three elements: a reason why the data is near enough (implicitly because the 86 is not too different from the 63 hundredths of a second), a pause which suggests reflection and evaluation (he doesn't believe this, actually 23 hundredths is quite large), a further reason to suspect the data (the lengths were measured wrongly by the girls). This reasoning 'on the hoof' suggests how the dialogue becomes an object for reflection once it has been voiced. The train of thought is therefore emergent. There are several such identifiable developments in the episode showing how utterances develop a chain of reasoning.

Later he gets a chance to shift the discussion from Stephanie's talk about gravity again, (justified for him because she made a mistake when she suggested that gravity varies with the height), and after again emphasizing that gravity is the same everywhere:

Daniel But different if the person letting go of the ball might be letting go of it different every time. So it might have a different effect on it. So it'd be easier if we could get something to do the letting go of the ball for us, the same every time. But we haven't got much equipment, like.

The discussion characterised in Groves (1997) analysis of this part of the episode as being 'about the data' is also in a sense, Daniel's. He seems finally to let go of this after it has been approved of and simultaneously dispensed with by me.

Julian That's a good idea ... we could try ....

Has this attention to the data obscured the possibility of Daniel learning from the dialogue? One is left with doubts, and the feeling that Daniel will benefit from some further experience with the practical work to assure himself of the data.

On the other hand we can cite evidence of his making sense of various points in the discussion, and of agreeing with the consensus reached at various points in the dialogue. Furthermore, later in the discussion Daniel re-enters to support Richard's interpretation that the ball is increasing in speed. He is happy that the data is explained. For Daniel it is 'obvious' that speeding up explains the data which he began the episode disputing. This shows clearly that he has moved

with the consensus, which represents 'progress' in the scientific discourse. How did this happen, and does it provide evidence of 'learning'?

A constructivist would argue that the individual's experience is central for the individual's learning. But here it seems that the social pressure in the group is strong, and that the individual experience may not be so significant in the development of a group discussion and its consensus. But has Daniel really accepted the social consensus, or does he 'really' believe something else? Perhaps his doubts about the data were ignored rather than convincingly confronted and dispensed with.

This provides an important example of the weakness of our evidence of learning. From just one episode, one cannot be sure the new, accepted explanation or way of thinking is more than ephemeral, and in some instances we may choose to believe that learning has occurred and on subsequent occasions find the new idea has slipped away. Where is the teacher who has not experienced this?

Finally we might speculate that the role of the teacher in the dialogue has been a major influence on Daniel's willingness to concede. The discussion would perhaps have been disputational in Mercer's sense (1995) without the adult management of the dialogue. If this is the case it is likely that in such circumstances Daniel would simply have made no progress.

Analysis 2: Stephanie leads the dialogue

Stephanie has shown in a previous session that she can develop explanations of motion using the concept of force as change in motion. In her opening explanation of the motion of the falling ball in this episode she appeals to gravity as a cause. But there is some lack of clarity about what she is trying to explain. She appears to compare the two motions (the first, dropped from higher up, has more gravity than the one dropped from lower down). I interpret (at the time) this to mean that she thinks gravity is greater higher up. This is contradicted by Daniel, and she appears immediately to agree and reformulate.

Stephanie It's not really an idea it's an explanation why it's only 63 and that's 43. Because there it's not got a lot of gravity pulling it down but up there it's got quite a lot, so it's pulling it down a lot quicker, so it's gone a bit slow, so that'd be 63. ... [Gravity's] pulling it down. ... Like from 43 it hasn't got as much gravity as it has from ...

Daniel Yes it has. It's got exactly the same!

Stephanie ... as from 95 to 190 because there it's not got as far for the gravity to pull it but up there it has got. So I think that's just about right.

Julian So you think it's got more gravity up there so it goes quicker, than it would do down there ... Stephanie says the higher up the more gravity so the time goes quicker?

Stephanie No, time doesn't go quicker, the ball goes quicker.

This is disputed by Kelly, who insists that gravity is always the same, that the weight of the ball stays the same. Stephanie reformulates, the gravity doesn't

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vary, but it has more time to act. Kelly and the rest of the group insist this is a new and better position.

Kelly Stephanie said that it's got more gravity than when it's up there , but I think that gravity is always the same. ... It's not like you're lifting different weights. It's the same weight.

Whether Stephanie really believed that gravity is greater higher up than lower down, that is what she offered and, indubitably, that is what the group took her to mean. It is clear in the tape that she almost immediately wanted to retract, and undertook another exposition, that gravity is the same everywhere but that it has more time to act if it is dropped from higher up:

Stephanie The gravity's the same all the time, but from up there the gravity's got more of a chance of pulling it. But from there it's got less chance because it's falling down ... like I say the gravity isn't different. It's because up there it's got more time to pull it. From there it's got hardly any time to pull it, because it's going down. So it's not the gravity that's different.

Finally, after consideration of Richard's point that the ball in fact is speeding up as it falls, (it becomes accepted that this explains the data collected) Stephanie offers a mental model of the speed of the falling ball based on the graph constructed for the velocity of a rolling ball collected the previous week (an activity based on Galileo's experiment, where strips of paper represent the speed of the ball rolling on a slope).

Stephanie It's like the ball experiment, it got — the strips got — shorter. So if we do it every second, if you imagine it stopped every second, and we measured that, it would be going longer, so it's like the other way round.

We interpret this as two discrete developments in Stephanie's explanation, and hence perhaps her understanding. The first seems to the group to be a change from "the more gravity the quicker it goes" to "gravity is the same but has greater time to pull it". But closer inspection suggests it may just be an increased precision in her use of language, from "more gravity", to "more chance to act" to "more time to act". This development is pushed by the questioning of the group, and by the re-focussing of the discussion onto her idea by my own interest.

The second discrete change in her understanding is from the idea that gravity has time to pull it more quickly to a mathematical model for the motion, i.e. her visualization of a strip graph representing the speed of the ball as it gains speed. This seems to be encouraged by the focussing of the discussion on the speed of the ball. Richard reminds us of the ball experiment in the previous week (in which strip graphs were used) because his explanation of the ball speeding up includes a non-verbal wave of his hand which recalls the rolling ball experiment.

Thus the clearest evidence of learning appears in Stephanie changing formulations within the dialogue, which serves as a means of assessing her growing understanding. We know she understood it because she played a large part in it.

Stephanie clearly makes a good deal of creative input of fresh and constructive ideas into the dialogue; she may be one of the more advanced peers who may help learners to construct knowledge precisely because they speak from a standpoint within the zone of proximal development of other learners. The dialogue is largely advanced on the basis of her ideas, with most student evaluations referring to what she had to say, and significant attempts to focus on her ideas being made by me.

On the other hand she also has apparently benefited greatly from the challenges of the dialogue. This may be because the need to communicate provides the motivation to verbalize (verbalization being presumed to be a facilitator of transferable learning as opposed to the tacit knowledge built up in much practical or craft learning). Or it may be because the dialogue allows her to hear what she is saying, and so reflect on her previous contributions once they are objectified in the dialogue. It is clear that she gains stimulation from testing her ideas against those of others, whether or not they are really more competent peers.

Analysis 3: Kelly, the sense-maker

Although Kelly takes some initiatives by introducing new ideas into the dialogue, the strongest impression of Kelly is that she learns by picking up and making sense of ideas put into the dialogue by others. Indeed her most positive contribution to the dialogue is precisely in her building on the ideas of others.

Initially she agrees with Daniel's doubts about the data and tries to explain why they might have made a mistake. But she listens to Stephanie's explanation and builds on this too. Kelly reflects on Stephanie's original formulation, pulls in Daniel's point that gravity is the same everywhere, and uses this to criticise Stephanie's point. This influences Stephanie, and Kelly finally shows her appreciation of the new position, and especially she shows she knows that the new explanation is different from the old (the fact that she made an important impact on the group may have given her a sense of ownership).

Later Kelly builds on Daniel's thoughts about redesigning the experiment, then when Richard explains that the ball speeds up, she evaluates Richard's contribution and makes sense of it in her own terms:

Julian	Why is that a good explanation, Kelly? Does that explain it? [Kelly nods.] Why?
Kelly	Well it's like I didn't think about speeding up, or anything. Like when Richard says that, when you come to think of it, you don't just stay the same speed all the time, like if you're in a race you don't just stay the same speed.

Finally she appreciates Stephanie's comparison with the experiment done last week, and though she "doesn't understand it" she says she can see the connection.

In all Kelly plays a central social role in the whole of the dialogue, and her appreciation of the explanations offered and her conviction she understands what has been said provides convincing evidence of her changing understanding: she understood that gravity had more time to act, and that this

was a different explanation, she understood that there was a change in speed, and that this explained the data collected. Finally, she saw the connection with the strip graph they made last week for representing the speed of a rolling ball.

On the other hand one wonders how robust her learning is. Is knowledge gained in such a discussion taken away (transferred) into new situations? A Piagetian psychologist would want to conduct an extended clinical interview to investigate what she 'really' understands. But I would argue that this introduces another artificial, social dynamic and the criticisms that Lave (1988) levels at psychological frames of problem solving seem to apply equally to the clinical interview as arbiter of what an individual 'really' understands.

The evidence of Kelly's mental development in the discussion is explicated in her actions in the dialogue, even though these are strongly suggestive of her listening activity. Her understanding may have been, at least partly, acquired through active listening. But the evidence we have available is the account she gives of herself through her utterances. Of course the uterances themselves are actions with an important mental component. It is evident that even as she expresses her understanding, "well when you come to think about it, you don't stay the same speed all the time", she develops it further.

Analysis 4: Richard, the side-liner stays awake (just)

In a previous lesson Richard put forward an animist explanation for the slowing down of a ball. Even if there is nothing to slow it, he said: " it's like me, the ball gets tired eventually". Here in this dialogue too, we see the animist analogy being used again to make sense of the motion, and making a connection here for him with the work done in the previous lesson. This is immediately regarded as positive by the others, (and Kelly, of course, takes it up and makes it her own). This focuses the dialogue on speed and change in speed as a central concept: this provokes an advance in the dialogue which the researcher encourages, because the agenda is to look for explanations of motion as change in speed (the Newtonian view).

Richard	I think it'll go faster downwards if you lift it higher up because it's like someone running, they've got to get a further run up to speed up and that's [the ball is] speeding up ... The ball is speeding up as it's going down because it's got a longer time to speed up.
All	Yes.
Kelly	That's good, that!
Julian	Why is that a good explanation, Kelly , does that explain it? [Kelly nods.] Why?
Kelly	Well it's like I didn't think about speeding up , or anything.

We have no evidence from his verbal contributions to the dialogue that Richard made changes in his thinking, but clearly his contribution to solving the problem is valued and has a significant positive impact on the discussion.

We are left then with an almost extreme case: we only know that Richard 'agreed' with the consensual points, to the extent that he failed to disagree, stayed awake, commented that he agreed that gravity is the same everywhere, and in non-verbal ways suggested some other agreements.

In any classroom, side-lining is an issue. Observations of teachers managing discussions in full classrooms show an attention to scattering questions to many children in an attempt to assess as many as possible, and to manage their behaviour. Such actions tend to destroy the dialogue as an inquiry, because they give attention to random contributions which often fail to build on previous utterances. Dialogue therefore requires us to assume that the listener is sharing the consensus, and hence learning to the extent that the dialogue progresses.

Analysis 5: Julian, teacher and researcher

I have the benefit in my analysis of knowing what I wanted to achieve through this discussion. The prime concern was to find out what the children thought about the conflict. The second concern was to see where the argument might lead, under my guidance where appropriate as a teacher.

At various moments in the discussion you can see summarising statements which attempt to make sense of the groups consensual belief, of course in my own terms. This mirrors the role of the children: they attempt to make sense of the problem, I attempt to make sense of their beliefs and reasons. They attempt to solve the problem, or resolve their differences; but I attempt to formulate their consensus, and help them focus on productive suggestions. These may somewhat reflect a chairperson's role (see Doig, 1997), and a teacher's role (see Groves, 1997) but they also reflect the role of a researcher who intends to learn; I am seeking to learn what the children believe and what they can construct together. I formulate my understanding of the individual or group and seek confirmation that this is correct or ask for a clarification if not. This difference in aims and goals does not destroy a dialogue: as Matusov (1996) argues, intersubjectivity does not necessarily reduce to consensus, or identity of goals and understandings.

Here, for instance, I summarise what Daniel has said, connect it with what he said about the data earlier, and mentally conclude that Daniel still needs to do more practical work if the discussion is to progress beyond questioning the data:

Julian — That's a good idea. So we could try and make sure we were letting go of it exactly the same every time. And that goes back to what you said earlier that 63 isn't very different from 86 anyway. There's only a little bit of a difference, 20 hundredths of a second. Yes that's interesting.

In another example, I summarise what Richard said about sprinting, and check my understanding of his thinking:

Julian — It's like someone sprinting — it takes a while to get up to speed. And you think that's what's happening to the ball?

On the other hand there are occasions when a new idea arises which seems to me to be productive of progress in scientific thinking. On two occasions at least I focus the group's attention to concepts. First, when I draw the discussion back from the data to ask for Stephanie to elaborate on gravity:

Julian — But I'm still interested in Stephanie's idea that the gravity is pulling it. Is it that gravity's pulling it quicker or ...?

Then again, when Richard introduces the concept of speed as a possible explanation:

Julian — Say that again. What's speeding up?

In both these instances, I evaluate without necessarily giving reasons. I see focusing as the selection of productive concepts or ideas which will take the discussion higher, but will inevitably require the children to make their own sense of it if they are to construct new understandings, i.e. to learn. These productive concepts and ideas in the dialogue form a scaffolding for children's cognitive learning (Wood, 1988). Because the teacher is in an academic learning environment, as opposed to the parental teaching of language through motherese, or the vocational contexts of instruction, (see eg Lave, 1988), the dialogue is constructed as a scaffolding from the participating children's utterances, selectively emphasised and focused by the teacher.

But every advance in the progress of discussion demands some checking, through summarising and eliciting of a consensus, or through requests for clarification. My final attempt to take the dialogue forward by focusing on Stephanie's strip-graph model for the motion of the ball dies out when the group fails to take this up and the dialogue wanders:

Julian — It takes longer to fall from higher up, but not as long as we thought and the reason it doesn't take as long as we thought it would, that's what I'm trying to get at. It's something to do with the ball speeding up and Stephanie thinks it's something to do with the strips and the rolling ball — and the strips of paper — but I don't understand the connection. Do you understand the connection?

Richard — No.

Julian — It was your brilliant idea that it was because the ball's going faster and that's why we were fooled.

The experience of teaching through such dialogue, even in a small group like this, is a task which puts the teacher under a constant tension. On the one hand, there is the pressure, let's say force, to attempt to advance the dialogue; on the other, there is the inertia or resistance in the need to check that the participants are making sense of it. The behaviour of the teacher in resolving the tension will be strongly influenced by their intentions.

In this dialogue I understood my role to be primarily to understand the beliefs of the children, which required me mainly to listen, check for sense, summarise and request clarification. The children's response to this respectful behaviour of a

guest was naturally to try to oblige me: to enlarge on their beliefs, explanations and reasons. The need for them to listen to each other as well as to explain to me was less evident, but after two sessions this social norm was beginning to emerge, too. And the lack of any problems of managing a large class too helped to accelerate these social processes.

Teaching and Learning: the teacher's role in scientific dialogue

Learning has been traditionally defined psychologically as a change in the state (behaviour, cognitive structure or competence) of an individual. In the foregoing analysis we have adopted this view, making inferences about the individual's cognition from their expressions of understanding, or from the consensus that the group appear to share. Thus the assessment of the psychological became a social process of interpreting the dialogue, which in any classroom is one of the roles of the teacher.

The analysis of the 'teacher's role' in the dialogue involved a re-conceptualization of the teacher here as a researcher inquiring into the everyday beliefs of the children, and their potential for growth. It was argued that the motives of the children in putting forward their views here was a response to this context. A teacher who adopts such a stance is one who is genuinely interested in inquiring into the children's conceptions, one who wants to understand the children's upward growing conceptions. Such a teacher therefore sees learning as a part of their role.

If such dialogue requires that the leader is really interested in what the children think and what they can develop, rather than in teaching them a specific body of knowledge, is it necessary to be a researcher-teacher in order to do this. Cannot a regular teacher be this interested in children's thinking, and hence lead a dialogue like this?

The teacher-researcher's role in summarising the progress in terms which make sense to them, therefore conceptualises the children's science in more mature scientific terms. This encourages (if not ensures) that scientific formulations have the opportunity to enter the dialogue. By focusing on 'productive' conceptualizations put forward by the children, the teacher further strengthens the opportunity for scientific ideas to enter the dialogue and provide opportunities for children to adopt them.

If the dialogue between children, and with the teacher, involves listening and sense making by all participants then we expect the dialogue to include within it the intertwining of more and less sophisticated conceptions, formulations or explanations, as each tries to make sense of the other. This is the structure of a scientific dialogue which can serve to promote individual's learning through the internalizing of the intramental. In Vygotsky's terms:

"The transformation of an interpersonal process into an intrapersonal one is the result of a long series of developmental events... " (Vygotsky, 1978; page 57).

This view of the teacher's role suggests that their elicitation and listening are central skills in their handling of effective dialogue. Teachers usually have these

skills, and what is required is that they see the dialogue as a significant means of children learning, and understand that their main role in this is to try to understand how the children think. This involves trying to assume the point of view of the learner, and making sense of their science in their own, mature scientific terms. Adopting such a model of teaching will then perhaps motivate the intentional interventions in the dialogue of the kind we have seen.

Theoretical reflections on activity theory and dialogue

The foregoing analysis of the dialogue benefited in two clear ways from the concepts of activity theory on which it drew. First, the dialogue is conceived of as the object of the individuals actions. Most of these actions are operationalised as utterances, but we include non-verbal action, such as agreement or disagreement, and the action of listening is of course crucial, (though the transcript evidence is a problem.)

The action (mostly the utterance) as a unit of analysis suggested we examine the personal intention of the subject (i.e. the participant who is speaking). This was especially important in the analysis of the 'teacher-researcher', whose intentions were known.

Second, the actions are placed within an activity system in which a complex of mediations take place. Thus the utterances are mediated by speech genres, and the discourse takes place in a social language (see Doig, 1997). And the intentions of the participants must be understood by seeing them in their community, with the division of labour determined by the wider social setting in which the activity emerges (Wells, 1996).

The understanding of the teacher researcher (the author) as specially situated, (we can say priveleged) helps in understanding how the dialogue came about, and leads to suggestions about how a 'real' teacher in an 'ordinary' classroom might act and how they might need to change their conceptions and intentions if they are to develop such dialogue.

In recent theoretical debate it has been suggested that sociocultural approaches might be more appropriate for macro-social analysis, and socioconstructivism for the microanalysis of individuals learning in the classroom. This would seem to be a counterexample. I do not doubt the value of theoretical positions which centre on the constructions of the child (eg in understanding their potential for subject development) , or the teacher (eg in developing reflective practice). However, activity theory seems here to help link an understanding of the nature of dialogue and the community of the classroom in which the teacher is a social operator.

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